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MULTIVARIATE CHARACTERIZATION OF UNDERUTILIZED ROSELLE (*HIBISCUS SABDARIFFA* L.) GENOTYPES FOR AGRO-MORPHOLOGICAL VARIATION, FRESH LEAF YIELD AND LEAF NUTRITIONAL QUALITY

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ABSTRACT
Roselle (*Hibiscus sabdariffa* L.) is an underutilized leafy vegetable with significant potential for improving food and nutritional security. However, information on the performance of roselle genotypes under rabi season cultivation and the nutritional characteristics of leaf remains limited. The present study evaluated thirty roselle genotypes for agro-morphological and physiological traits under rabi season using multivariate approaches and identified superior genotypes through selection index analysis, followed by biochemical characterization of selected elite lines. The experiment was conducted in a randomized complete block design with three replications at Tamil Nadu Agricultural University, Coimbatore, India. Significant variation was observed among the evaluated genotypes for all studied morphological and physiological traits. Genotype 23 recorded superior performance for plant height, stem diameter, leaf area index, and average fresh leaf yield per plant per picking, while G15 exhibited the highest ascorbic acid, total phenol and total soluble solids contents together with the lowest oxalate content among the elite genotypes. Correlation analysis revealed strong positive associations of fresh leaf yield with plant height and leaf area index. Principal component and cluster analyses further confirmed diversity among the evaluated genotypes and supported the identification of superior lines. The findings demonstrate the availability of valuable genetic variability in roselle and identify promising genotypes for improving fresh leaf yield and nutritional quality. These elite genotypes may serve as useful genetic resources for developing high-yielding, nutritionally superior roselle cultivars adapted to rabi season cultivation under Coimbatore conditions.

KEYWORDS: underutilized leafy vegetable, roselle, multivariate analysis, fresh leaf yield, genotype evaluation.

1. INTRODUCTION

As consumers have become increasingly health-conscious, there has been growing interest in underutilized leafy vegetables because of their nutritional and medicinal benefits. Roselle (*Hibiscus sabdariffa* L.), a member of the Malvaceae family, is one such underutilized crop that has gained recognition for its diverse food, medicinal, and economic importance ***(Adobe et al., 2026)***. Initially, it was cultivated as a fibre crop; it is now widely used for its edible calyces, seeds, and tender leaves.

Roselle leaves are rich sources of vitamins, minerals, dietary fibre, and many bioactives, including phenols and flavonoids, which contribute to their antioxidant, anti-inflammatory, and anti-diabetic properties ***(Bora et al., 2026; Edo et al., 2023)***. In South India, the leaves are traditionally consumed as "Gongura" and form a part of the local diet ***(Sashidevi et al., 2018)***. Despite their nutritional and widespread culinary use, research on roselle has predominantly focused on the calyces and seeds, while comparatively less attention has been given to the leaves, particularly with respect to genotype evaluation and nutritional characterization.

Roselle exhibits considerable genetic variability for morphological, physiological and quality traits, providing significant opportunities for crop improvement through selection and breeding ***(Phukon et al., 2025)***. However, systematic evaluation of available germplasm for fresh leaf production remains limited, restricting the identification of superior genotypes suitable for cultivation and future breeding programmes. Furthermore, most available studies have roselle under conventional growing seasons, whereas information on genotype performance

under rabi season cultivation is scarce. Evaluating roselle during the rabi season is important for identifying genotypes capable of maintaining satisfactory growth, productivity and nutritional quality under relatively cooler environmental conditions, thereby facilitating the development of suitable off-season cultivars.

Multivariate approaches such as correlation analysis, principal component analysis and cluster analysis are useful for assessing trait relationships, identifying major sources of variation and grouping of genotypes based on overall performance. Hence, the present study was undertaken to evaluate thirty roselle genotypes for agro-morphological and physiological performance under rabi season cultivation, identify superior genotypes using a selection index, and characterize the biochemical attributes of selected elite genotypes to identify promising genetic resources for fresh leaf production and future breeding programmes.

2. MATERIALS AND METHODS

2.1 EXPERIMENTAL SITE, DESIGN AND PLANT MATERIAL

The field experiment was conducted during the rabi season of 2025-26 at the orchard, Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, India (11.00755° N, 76.92821° E, 426.7 m above mean sea level). During the crop growth period, the mean maximum and minimum temperatures were 32.0° C and 20.6° C, respectively, with an average annual rainfall of 574.7mm. Thirty roselle genotypes (*Hibiscus sabdariffa* L.) collected from different regions of South India (Table 1) were evaluated in a randomized complete block design (RCBD) with three replications. Thirty plants were maintained for each genotype under a paired row system in plots of 8 × 0.9 m. Seeds were sown on 19th December, 2025, in raised beds at a spacing of 60 x 60 cm within the bed, with 90 cm between adjacent beds. A fertilizer dose of NPK at 60:40:40 kg ha^{-1} was applied. The crop was irrigated through a drip irrigation system.

2.2 RECORDING OF MORPHO-PHSYIOLOGICAL TRAITS

Observations were recorded for plant height (cm), stem diameter (cm), number of branches per plant, number of calyces per plant, number of parted lobes on leaves, chlorophyll content (SPAD units), leaf area index (LAI), and average fresh leaf yield per plant per picking (g). Morphological and physiological observations were recorded from five randomly tagged plants in each plot, and the mean values were used for statistical analysis. The morphological descriptors were recorded according to the descriptor guidelines provided by (Daudu et al., 2019).

2.3 PREPARATION OF PLANT SAMPLES FOR BIOCHEMICAL ANALYSIS

Based on the selection index derived from morphological and physiological traits, eight elite genotypes were selected for biochemical analysis. Fresh roselle leaves from these genotypes were collected and divided into two portions. One portion was used immediately for the estimation of ascorbic acid and total soluble solids (TSS). The remaining portion (50g) was dried in a hot air oven at 60° C until constant weight, ground into a fine powder, stored in airtight containers at 4-6° C, and used for the estimation of total phenols, crude fibre, and oxalate.

2.4. ESTIMATION OF ASCORBIC ACID

Ascorbic acid was estimated by the 2,6 - dichlorophenolindophenol (DCPIP) volumetric method following Sadasivam and Balasubramanian (1987). Fresh leaf tissue (5g) was homogenized in 4% oxalic acid, filtered through Whatman No. 1 filter paper, and the final volume was made up to 50 mL with 4% oxalic acid. A 5ml aliquot of the extract was mixed with 5ml of 4% oxalic acid and titrated against DCPIP solution until a persistent light pink colour was observed. Ascorbic acid content was expressed as mg AA 100 g^{-1} fresh weight (FW)

2.5 TOTAL PHENOL ESTIMATION

Total phenol content was determined following the method of Bray and Thorpe (1954) using gallic acid as the reference standard. Dried leaf powder was extracted with 80% ethanol and the extract was mixed with Folin-Ciocalteu reagent followed by 20% sodium carbonate solution. Absorbance was recorded spectrophotometrically at 650nm and the total phenol content was expressed as mg GAE g^{-1} dry weight (DW).

2.6 TOTAL SOLUBLE SOLIDS ESTIMATION

Total soluble solids (TSS) were measured using a handheld refractometer. Fresh leaf tissue (1-2 g) was ground using a mortar and pestle. The extract sap was placed on the prism of the refractometer. The TSS value was recorded as ° Brix.

2.7 DETERMINATION OF CRUDE FIBER CONTENT

Crude fiber content was estimated according to the AOAC official method 978.10 (“Official Methods of Analysis: 15th Edition,” 1990) with slight modifications. Dried leaf powder (1-2 g) was subjected to successive acid and alkali digestion using 1.25% H_2SO_4 and 1.25% NaOH, respectively, for 30 minutes each. The residue obtained was oven-dried at 105° C, weighed, incinerated in a muffle furnace at 550° C, and the weight was recorded again. Crude fibre content was calculated from the loss in weight after washing and expressed as percentage (%).

$$\text{Crude Fibre \%} = \frac{\text{(Weight of dried residues - Weight of ash)}}{\text{Weight of sample}} \times 100$$

2.8 OXALATE ESTIMATION

The total oxalate content was determined volumetrically via permanganate titration as described by Mishra et al. (2017). Dried leaf powder (1 g) was extracted with 0.5N H_2SO_4, and the extract was heated to approximately 60° C before titration against standardized 0.05N $KMnO_4$ until a persistent light pink endpoint was obtained. Oxalate content was expressed as percentage (%).

3. STATISTICAL ANALYSIS

All statistical analyses were performed using Microsoft Excel Analysis ToolPak and an online statistical tool (*https://www.statskingdom.com/about.html*, 2017). Analysis of variance (ANOVA) was carried out under a randomized complete block design (RCBD) to test the significance of differences among genotypes. Treatment means were compared using Duncan's Multiple Range Test (DMRT) at a 5% level of significance. A selection index was calculated using standardized values of morphological and physiological traits to identify superior genotypes for fresh leaf production. Pearson's correlation analysis was performed to determine the associations among traits, and principal component analysis (PCA) was used to identify the major traits contributing to variation among genotypes. Hierarchical cluster analysis was performed to group genotypes based on trait similarity.

4 RESULTS

4.1. MORPHOLOGICAL TRAITS

Significant variations were observed among the 30 roselle genotypes for all morphological traits evaluated (Table 2), showing the presence of genetic variability within the experimental material. Plant height ranged from 34.83 cm in G26 to 198.03 cm in G23. Stem diameter varied from 1.18 cm (G14) to 3.95 cm (G23). Genotypes 23, 21 and 20 recorded the highest number of branches (5.67 $plant^{-1}$), whereas G11 recorded the fewest branches (3.33 $plant^{-1}$). The number of calyces per plant varied clearly among the genotypes, with G15 producing the maximum number of calyces (80.67), while G24 and G11 did not flower during the experimental period. Variations were also observed in leaf morphology as well, with G4 and G21 recording the highest number of leaf lobes (5.67), whereas G8 and G9 exhibited single-lobed leaves. Visual differences in plant morphology, leaf shape, and flowering habit were also evident among the evaluated genotypes, as shown in Fig. 1 and Fig. 2

4.2. PHYSIOLOGICAL TRAITS AND FRESH LEAF YIELD

Chlorophyll content, leaf area index (LAI), and average fresh leaf yield per plant per picking varied significantly among the evaluated roselle genotypes (Table 3.) Chlorophyll content ranged from 27.71 SPAD units in G17 to 52.77 SPAD units in G4. Leaf area index varied between 1.193 in G14 and 4.247 in G23. Average fresh leaf yield per plant per picking ranged from 19.60 g in G8 to 76.23 g in G23. Genotype G23 recorded the highest leaf area index and fresh leaf yield, whereas G4 recorded the highest chlorophyll content.

4.3 SELECTION OF ELITE GENOTYPES

Based on the combined performance for morphological and physiological traits, a selection index was calculated to identify superior roselle genotypes (Table 4). Eight elite genotypes, namely G23, G4, G15, G30, G21, G29, G20 and G10, recorded the highest selection index values and were selected for further biochemical evaluation. Among these, G23 recorded the highest selection index score (8.408), followed by G4 (5.065) and G15 (4.209).

4.4. BIOCHEMICAL CHARACTERIZATION OF ELITE GENOTYPES

Considerable variation was observed among the eight elite roselle genotypes for all the biochemical traits evaluated (Table 5). Ascorbic acid content ranged from 20.17 mg AA 100 g^{-1} FW in G30 to 53.56 mg AA 100 g^{-1} FW in G15. Total phenol content varied from 33.10 mg GAE g^{-1} DW in G4 to 40.24 mg GAE g^{-1} DW in G15. Total soluble solids (TSS) ranged from 3.76° Brix in G4 to 4.4° Brix in G15. Crude fibre content ranged from 22.03% in G15 to 27.5% in G4, while oxalate content varied between 0.727% in G15 and 0.93% in G30. Among the selected genotypes, G15 recorded the highest ascorbic acid, total phenol and TSS contents, along with the lowest oxalate content. G4 recorded the highest crude fibre content, whereas G30 recorded the highest oxalate concentration.

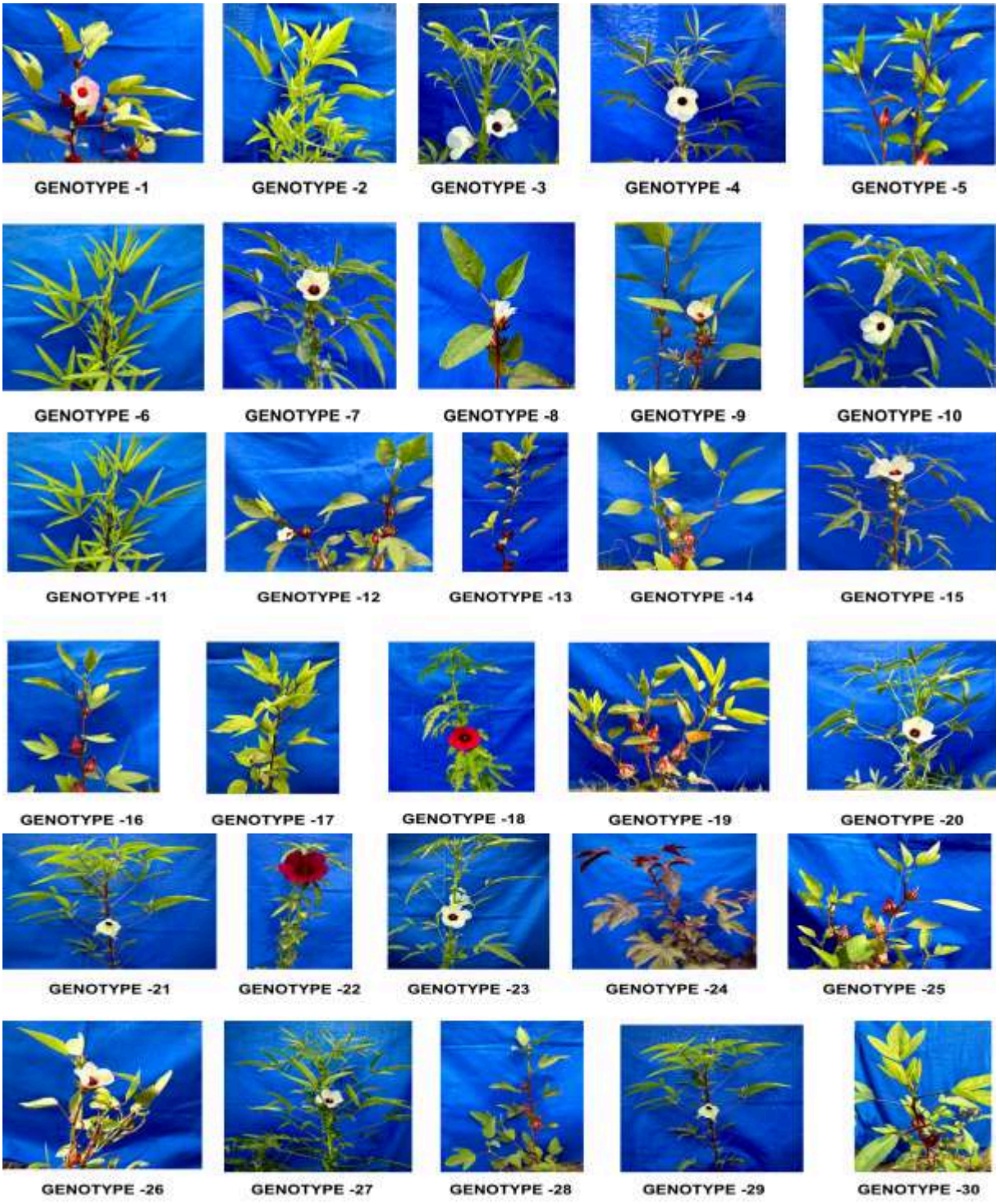
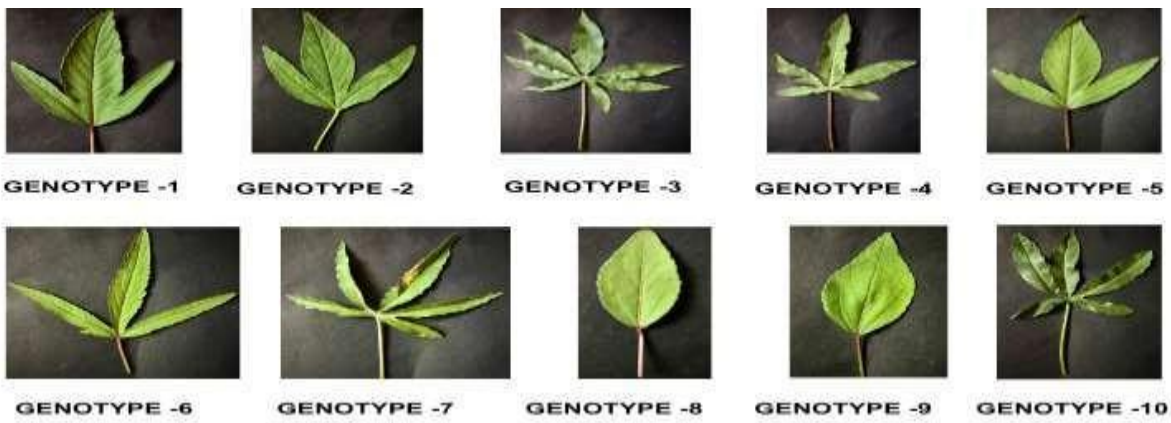


Fig 1. Phenotypic variations observed among thirty roselle genotypes evaluated under rabi season cultivation. Genotypes correspond to the germplasm details represented in Table 1.



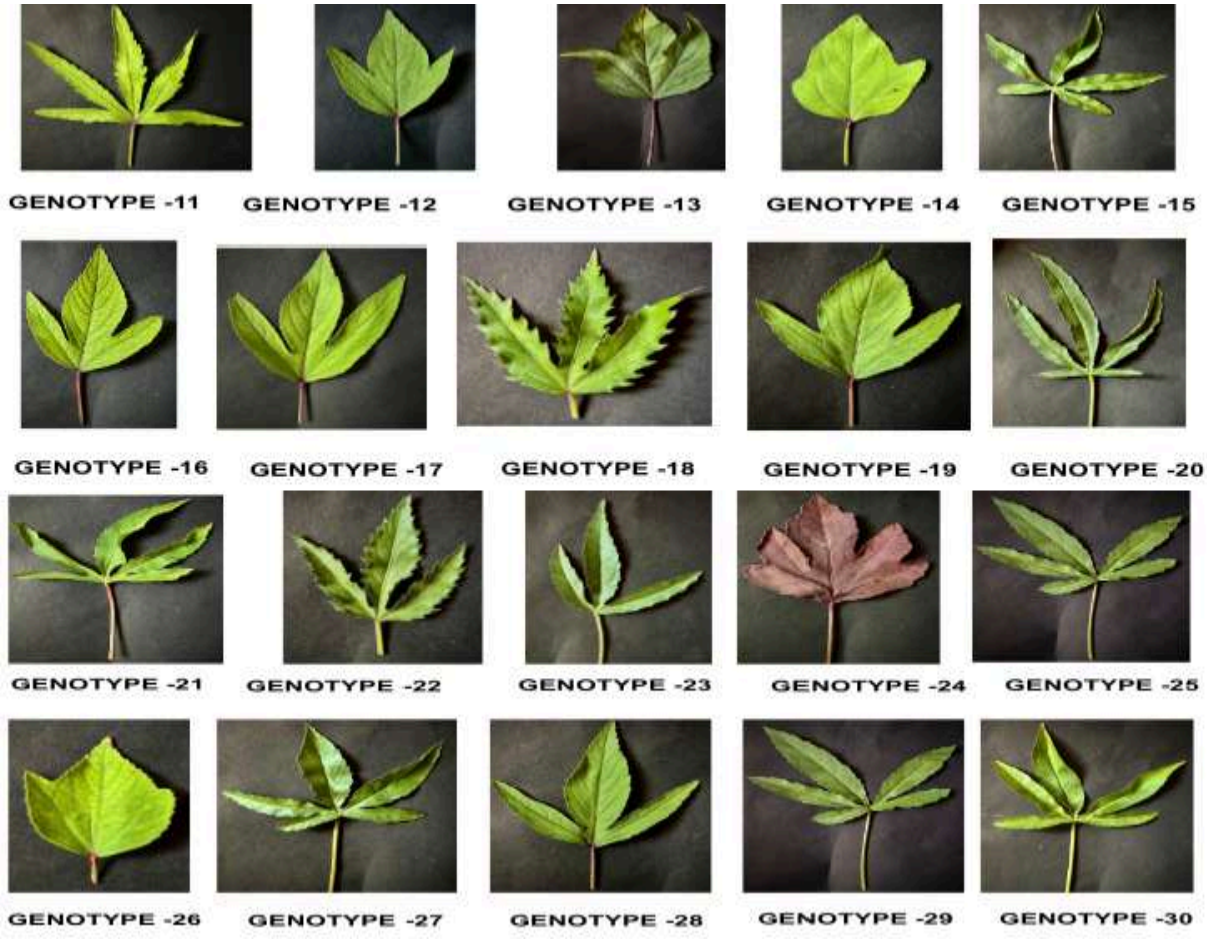


Fig.2 Morphological variation in leaf shape and number of parted lobes among thirty roselle genotypes. Genotypes correspond to the germplasm details represented in Table 1.

4.5. CORRELATION ANALYSIS

Pearson's correlation analysis revealed significant positive associations among the evaluated morpho-physiological traits (Table 6). Fresh leaf yield showed strong positive correlations with plant height (r= 0.80) and leaf area index (r= 0.80), followed by the number of branches per plant (r= 0.65), stem diameter (r= 0.51), and chlorophyll content (r= 0.45). Plant height was positively correlated with stem diameter (r= 0.73) and leaf area index (r= 0.76), while leaf area index also showed significant positive associations with stem diameter (r= 0.57) and number of branches per plant (r= 0.55).

4.6. PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (PCA) was performed to assess the pattern of variation among the roselle genotypes based on the evaluated morpho-physiological traits (Fig. 3). The first two principal components accounted for

78.69 % of the total variation, with PC1 and PC2 explaining 65.24% and 13.45% of the variation, respectively. The scree plot showed a sharp decline in eigenvalues after PC1, with PC1 recording an eigenvalue of 3.941 (Fig. 4). The PCA biplot showed that plant height, stem diameter, number of branches, leaf area index, and fresh leaf yield were oriented in a similar direction, indicating positive association among these traits. Genotype 23 was positioned close to these trait vectors, reflecting its superior performance for major yield based traits. While genotypes located away from these vectors exhibited comparatively lower performance. The PCA effectively differentiated the genotypes based on their overall performance and supported the identification of superior lines for fresh leaf production.

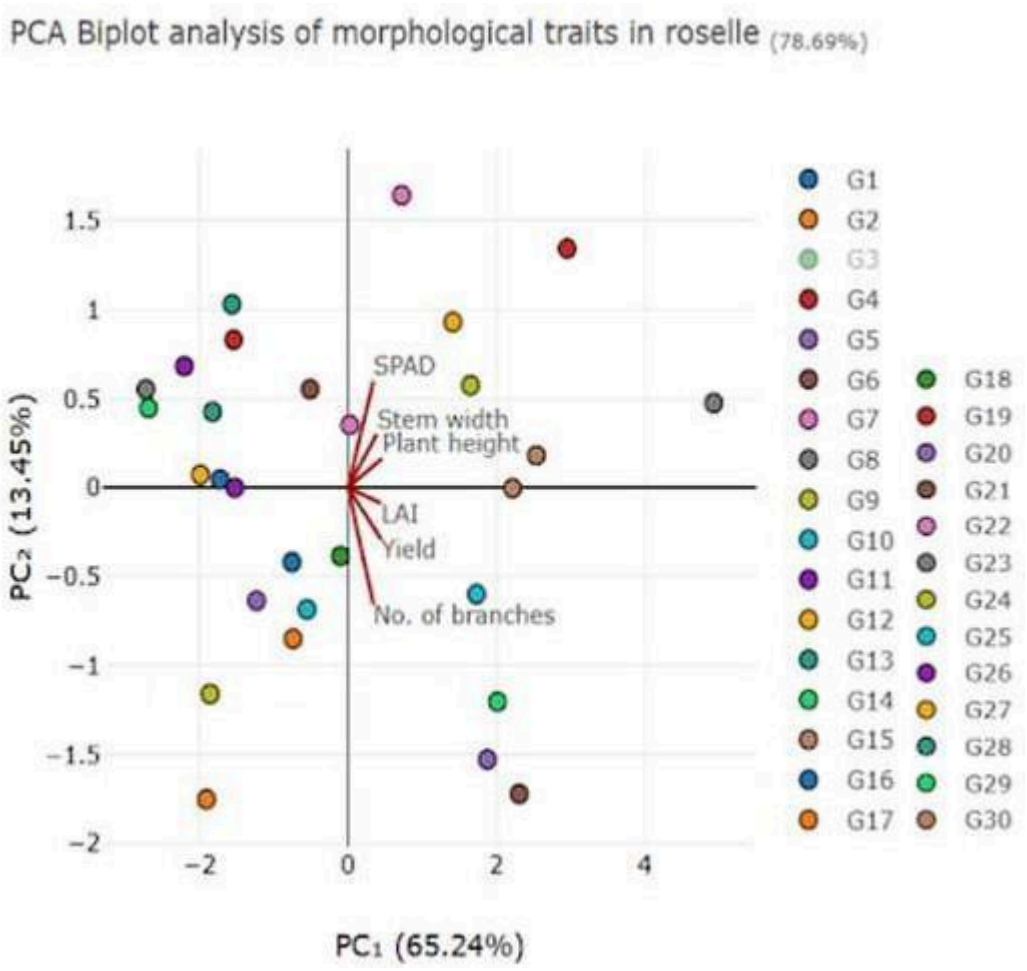


Fig 3. Principal component analysis (PCA) biplot illustrating the distribution of 30 roselle (*Hibiscus sabdariffa* L.) genotypes and the association among morpho-physiological traits. Each colour in the circle represents the corresponding genotype.

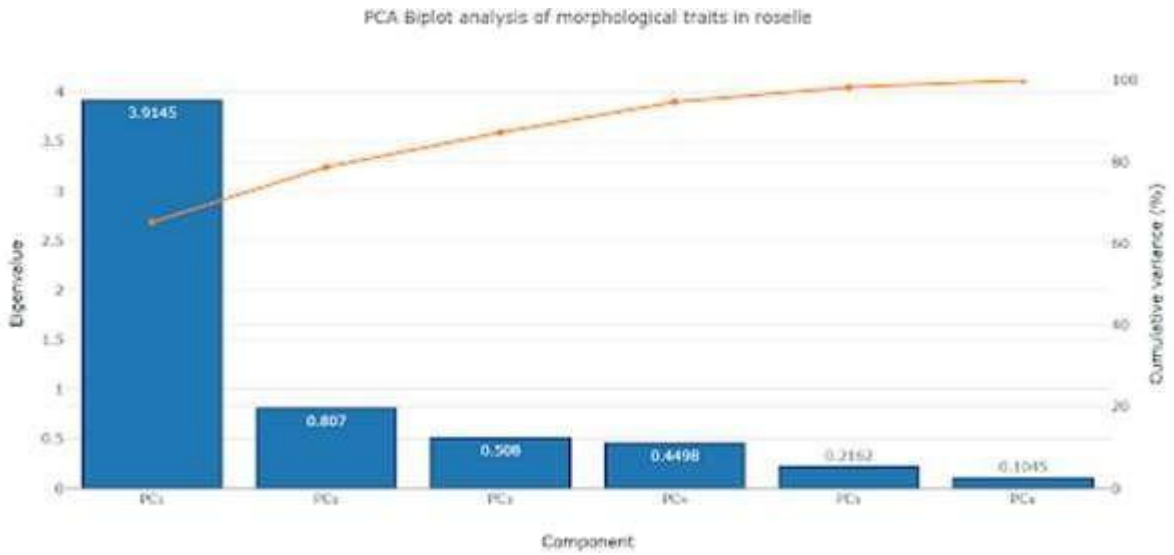


Fig 4. Scree plot showing the eigenvalues and cumulative percentage of variance explained by the first six principal components derived from PCA of morpho-physiological traits in 30 roselle (*Hibiscus sabdariffa* L.) genotypes. The y axis is representing the eigenvalues while the x axis is representing the PCA components.

4.7. CLUSTER ANALYSIS

Hierarchical cluster analysis grouped the thirty roselle genotypes into distinct clusters based on their morpho-physiological characteristics (Fig. 5). Genotypes with similar trait performance were grouped together, whereas genetically divergent genotypes were placed in separate clusters. G23 formed a separate cluster from many of the

remaining genotypes, reflecting its superior overall performance for several traits. The clustering pattern was largely consistent with the results of the principal component analysis and selection index, confirming the presence of diverse genotypes with contrasting performance.

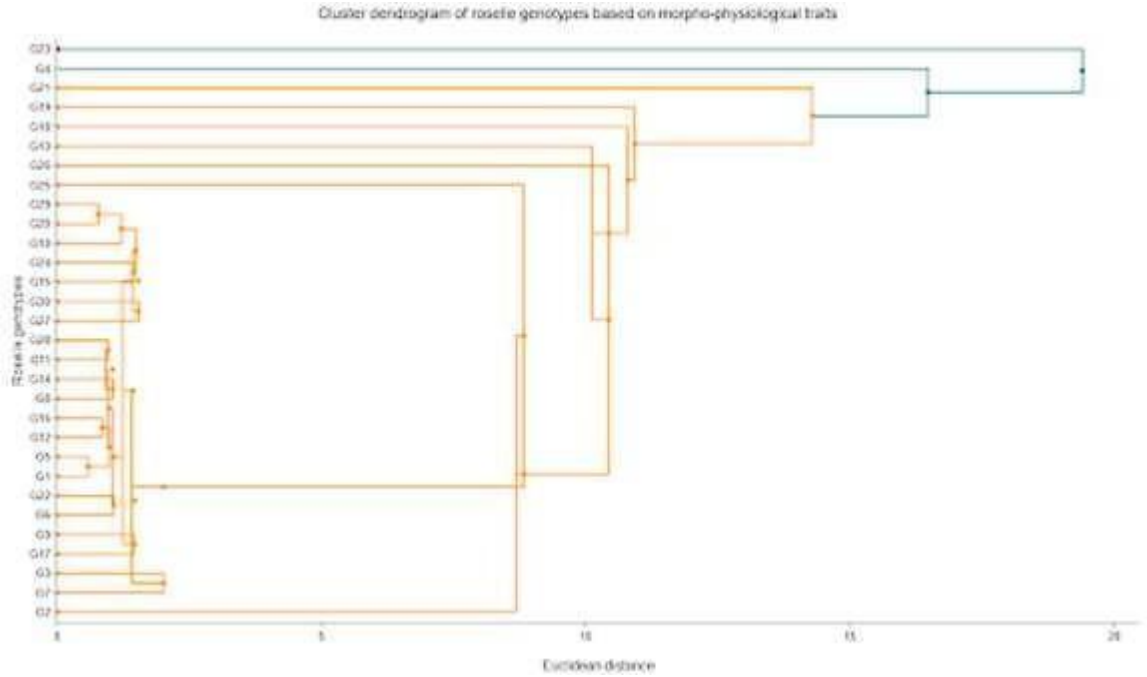


Fig 5: Hierarchical cluster dendrogram generated using average linkage clustering based on Euclidean distance, illustrating the grouping of 30 roselle (*Hibiscus sabdariffa* L.) genotypes according to their morpho-physiological traits. The y axis is representing the roselle genotypes and the x axis is representing the euclidean distance.

5. DISCUSSION

The variations observed among the thirty roselle genotypes for morphological, physiological and fresh leaf yield traits indicate the presence of useful variability within the evaluated germplasm. Such variation is essential for effective selection, particularly in underutilized crops where systematic genotype evaluation is limited. Furthermore, it suggests that the evaluated germplasm can be exploited for fresh leaf production under rabi season cultivation in Coimbatore conditions.

Among the evaluated genotypes, G23 showed superior performance for several important growth and yield-related traits, including plant height, stem diameter, leaf area index, and average fresh leaf yield per plant per picking. The high fresh leaf yield of G23 may be associated with its greater vegetative growth and higher leaf area index, which together can contribute to increased leaf biomass. In leafy vegetables, traits such as plant height, branching ability, and leaf area development are important because they directly influence the photosynthetic surface and harvestable biomass. The correlation analysis further supported the importance of vegetative growth traits in determining fresh leaf yield. Fresh leaf yield showed strong positive associations with plant height and leaf area index, followed by number of branches, stem diameter, and chlorophyll content. This indicates that genotypes with taller growth, greater leaf area, and better vegetative development are more likely to produce higher fresh leaf yield. The positive association between leaf area index and yield is relevant because leaf area directly contributes to light perception and biomass accumulation. Hence, plant height and leaf area index may serve as useful selection criteria for identifying high-yielding roselle genotypes.

The results of principal component analysis confirmed that a major proportion of the variation among genotypes was explained by the first two principal components. The grouping of plant height, stem diameter, number of branches, leaf area index and fresh leaf yield in a similar direction in the PCA biplot indicated that these traits contributed together to differences among genotypes. Furthermore, the positioning of genotype 23 close to the yield-associated trait vectors supports its superior performance. Likewise, hierarchical cluster analysis grouped genotypes based on overall morpho-physiological performance, and G23 was found to form a separate cluster from the remaining genotypes. The consistency among selection index, PCA, and cluster analysis additionally supports the distinct performance of G23 for fresh leaf production.

The use of a selection index helped in identifying eight elite genotypes by considering multiple traits related to vegetative growth and fresh leaf yield. This is important because selection based on a single trait may overlook genotypes with balanced overall performance. The subsequent biochemical profiling of the selected lines helped differentiate genotypes with high field performance from those with superior nutritional quality. Biochemical characterization of the selected elite genotypes exhibited significant variation for ascorbic acid, total phenol, total soluble solids, crude fibre and oxalate content. Among the elite lines, G15 showed the highest ascorbic acid, total phenol and TSS contents, along with the lowest oxalate content. Higher ascorbic acid and phenol contents are

desirable from a nutritional and functional food standpoint, while lower oxalate content is favourable because oxalate is generally considered an anti-nutritional factor.
From the results, it can also be inferred that no single genotype was superior for all traits. This suggests the need for trait-specific selection, where G23 may be prioritized for yield improvement and G15 for increased leaf nutritional quality, specifically for higher ascorbic acid and phenol content with lower oxalate levels.

6. CONCLUSION

The present study demonstrated substantial morpho-physiological and biochemical variability among the evaluated roselle (*Hibiscus sabdariffa* L.) genotypes under rabi season cultivation. The association of fresh leaf yield with vegetative traits, together with the separation of genotypes through principal component and cluster analyses, showed the usefulness of multivariate evaluation in identifying promising roselle genotypes. Among the evaluated material, G23 was identified as a promising genotype for fresh leaf production, while G15 showed superior leaf nutritional quality. These elite genotypes constitute valuable genetic resources for future roselle breeding programmes aimed at improving fresh leaf yield and nutritional quality.

7. ACKNOWLEDGEMENTS

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8.FUNDING

The authors did not receive any funding for conducting this study.

9. COMPETING INTERESTS

The authors declare no competing interests.

10. AUTHOR CONTRIBUTIONS

Data curation and formal analysis [Mahima Sridhar]; Investigation and methodology [G. Ashokkumar, T. Shanmugasundaram, Mahima Sridhar]; Project administration and supervision [C. Indu Rani, G. Ashokkumar, T. Shanmugasundaram, V.Thiruvengadam, K. Gurusamy]; Visualization and writing - original draft [Mahima Sridhar]; writing - review and editing [G. Ashokkumar, Mahima Sridhar]

11. DATA AVAILABILITY

All data generated or analysed for this study are included in the published work

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TABLE 1. LIST OF GENOTYPES USED IN THE STUDY

GENOTYPE	ORIGIN OF LANDRACE
HS-01	Nellore, Andhra Pradesh
HS-02	Pudukottai, Tamil Nadu
HS-03	Nellore, Andhra Pradesh
HS-04	Musiri, Tamil Nadu
HS-05	Pudukottai, Tamil Nadu
HS-06	Hyderabad, Telangana
HS-07	Thanjavur, Tamil Nadu
HS-08	Mysore, Karnataka
HS-09	Andhra Pradesh
HS-10	Ottanchathiram, Tamil Nadu
HS-11	Hyderabad, Telangana
HS-12	Ottanchathiram, Tamil Nadu
HS-13	Vellore, Tamil Nadu
HS-14	Coimbatore, Tamil Nadu
HS-15	Pudukottai, Tamil Nadu
HS-16	Pudukottai, Tamil Nadu
HS-17	Musiri, Tamil Nadu
HS-18	Vellore, Tamil Nadu
HS-19	Namakkal, Tamil Nadu
HS-20	Pudukottai, Tamil Nadu
HS-21	Vellore, Tamil Nadu
HS-22	Hyderabad, Telangana
HS-23	Nagarkurnool, Telangana
HS-24	Pudukottai, Tamil Nadu
HS-25	Pudukottai, Tamil Nadu
HS-26	Nagarkurnool, Telangana
HS-27	Andhra Pradesh
HS-28	Tiruchirapalli, Tamil Nadu
HS-29	Hyderabad, Telangana
HS-30	Nagarkurnool, Telangana

TABLE 2: MORPHOLOGICAL TRAIT VARIATION AMONG 30 ROSELLE GENOTYPES.

PLANT HEIGHT (cm)		STEM DIAMETER (cm)		No. of BRANCHES		No. OF CALYCES PER PLANT		No. Of PARTED LOBES	
G23	198.03a	G23	3.95a	G23	5.67a	G15	80.67a	G4	5.67a
G15	161.23b	G27	3.48b	G21	5.67a	G23	76.33a	G21	5.67a
G4	159.17b	G7	3.35b	G20	5.67a	G20	66.67b	G10	5.33ab
G30	146.10c	G30	3.33b	G30	5.33ab	G10	40.0c	G20	5.33ab
G20	144.73c	G3	2.99c	G29	5.33ab	G30	38.33c	G24	5.33ab
G10	144.43c	G21	2.90cd	G2	5.33ab	G21	37.33cd	G3	5.0ab
G24	141.70d	G22	2.77d	G10	5.33ab	G29	33.0d	G23	5.0ab
G3	140.77de	G15	2.52e	G9	5abc	G4	32.67d	G29	5.0ab
G27	138.97de	G6	2.45ef	G3	5abc	G22	18.67e	G30	4.67abc
G29	138.73e	G13	2.41efg	G26	5abc	G18	17.67ef	G7	4.33bcd
G6	122.83f	G24	2.40efg	G18	5abc	G6	15.33efg	G11	4.33bcd
G21	99.97g	G10	2.32fgh	G15	5abc	G7	14.0efgh	G15	4.33bcd
G25	98.53gh	G2	2.28fgh	G5	4.67abcd	G27	13.0fghi	G27	4.33bcd
G22	96.63h	G4	2.26gh	G4	4.67abcd	G3	11.67ghij	G13	3.67cde
G11	80.63i	G25	2.22hi	G25	4.67abcd	G12	11.33ghij	G16	3.67cde
G7	76.23j	G20	2.17hi	G17	4.67abcd	G16	11.33ghij	G19	3.67cde
G13	71.50k	G29	2.07ij	G1	4.67abcd	G5	10.33ghij	G1	3.33de
G18	68.53l	G1	1.91jk	G7	4.33bcde	G1	9.0hij	G5	3.33de
G1	62.9m	G26	1.86k	G27	4.33bcde	G26	8.33hij	G12	3.33de
G28	61.47m	G11	1.76kl	G24	4.33bcde	G19	8.0ij	G17	3.33de
G19	53.70n	G5	1.73kl	G22	4.33bcde	G25	8.0ij	G18	3.33de
G2	52.47n	G28	1.63l	G16	4.33bcde	G9	7.67ij	G22	3.33de
G16	49.63o	G12	1.60l	G12	4.33bcde	G28	7.0j	G25	3.33de
G12	45.30p	G16	1.36m	G6	4.0cde	G13	6.33j	G28	3.33de
G8	44.83pq	G9	1.37m	G8	3.67de	G8	6.0j	G2	3.0e
G14	44.27pq	G8	1.33m	G28	3.67de	G2	5.67j	G6	3.0e
G17	42.37qr	G18	1.33m	G19	3.67de	G14	5.67j	G14	3.0e
G5	41.33r	G17	1.28m	G13	3.67de	G17	5.67j	G26	3.0e
G9	37.80s	G19	1.27m	G14	3.33e	G24	-	G8	1.0f
G26	34.83s	G14	1.18m	G11	3.33e	G11	-	G9	1.0f

TABLE 3: PHYSIOLOGICAL AND YIELD RELATED TRAITS OF 30 ROSELLE GENOTYPES

CHLOROPHYLL CONTENT (SPAD UNITS)		LEAF AREA INDEX		AVERAGE YIELD/ PLANT IN ONE PICKING (g plant^{-1} picking^{-1})	
G4	52.77a	G23	4.25a	G23	76.23a
G23	47.83b	G15	4.013ab	G21	73.23ab
G7	45.6bc	G21	3.91b	G29	73.13ab
G3	43.03cd	G4	3.41c	G4	71.67b
G15	42.9cd	G29	3.39c	G20	67.43c
G18	42.87cd	G24	3.22cd	G10	66.83c
G24	42.0cd	G20	3.08d	G24	62.73d
G30	41.13de	G7	2.47e	G30	62.5d
G19	40.8de	G10	2.46e	G27	57.2e
G10	40.23def	G30	2.43ef	G15	56.53e
G26	40.03defg	G22	2.33efg	G18	55.3ef
G27	39.77defgh	G27	2.26efgh	G25	52.43f
G29	37.77efghi	G1	2.17fgh	G17	44.8g
G16	37.07efghij	G5	2.11ghi	G22	41.23h
G22	36.33fghijk	G16	2.09ghij	G3	40.77hi
G12	36.27fghijk	G6	2.03hij	G19	40.1hi
G20	36.1fghijk	G18	1.87ijk	G1	38.8hij
G1	35.93ghijk	G28	1.82jkl	G7	37.47ijk
G13	35.77hijk	G19	1.73kl	G5	35.87jkl
G2	35.6hijk	G17	1.71kl	G14	35.1kl
G8	35.13ijk	G3	1.7kl	G2	34.57kl
G5	34.87ijk	G2	1.61klm	G6	34.2kl
G28	34.8ijk	G13	1.57lmn	G9	34.13kl
G21	34.77ijk	G12	1.42mno	G28	32.43lm
G6	34.4ijk	G11	1.37mno	G11	29.27m
G14	34.17ijk	G25	1.3no	G13	25.37n
G9	33.5ijk	G8	1.28o	G12	24.07no
G25	32.7jk	G9	1.27o	G16	22.17nop
G11	32.43k	G26	1.23o	G26	21.8op
G17	27.7l	G14	1.19o	G8	19.6p

TABLE 4. ELITE ROSELLE GENOTYPES IDENTIFIED THROUGH SELECTION INDEX ANALYSIS

RANK	GENOTYPE	RESCALED SELECTION INDEX
1	G23	8.41
2	G4	5.06
3	G15	4.21
4	G30	3.84
5	G21	3.82
6	G29	3.26
7	G20	3.10
8	G10	2.93

TABLE 5. BIOCHEMICAL PROFILE OF ELITE ROSELLE GENOTYPES

ASCORBIC ACID (mg AA 100 $g^{-1)}$		**TOTAL PHENOL (**mg GAE g^{-1} dry weight)		**TSS (**° Brix.)		**CRUDE FIBRE** (%)		**OXALATE** (%)	
G15	53.36a	G15	40.24a	15	4.4a	4	27.5a	30	0.93a
G21	46.47b	G30	39.37b	10	4.21b	30	26.85b	4	0.89b
G10	46.44b	G29	38.33c	21	4.077c	23	26.51c	29	0.87c
G23	27.9c	G20	36.76d	29	3.92d	29	25.27d	20	0.83d
G20	27.83c	G21	35.37e	20	3.91d	20	24.35e	23	0.81e
G29	25.66d	G10	34.63f	23	3.86e	10	23.38f	10	0.79f
G4	20.93e	G23	33.78g	30	3.80f	21	23.15g	21	0.75g
G30	20.76e	G4	33.1h	4	3.76f	15	22.03h	15	0.73h

TABLE 6: CORRELATION MATRIX OF MORPHOLOGICAL AND YIELD RELATED TRAITS:

Characters	**SPAD**	**LAI**	**Branches**	**Stem width**	**Plant height**	**Yield**
SPAD	1	0.53*	0.27	0.49*	0.59*	0.45*
LAI		1	0.55*	0.57*	0.76*	0.80*
Branches			1	0.42*	0.46*	0.65*
Stem width				1	0.73*	0.51*
Plant height					1	0.80*
Yield						1

TABLE 7: PCA SCORES OF 30 ROSELLE GENOTYPES

Genotype	PC1	PC2	PC3	PC4	PC5	PC6
G1	-0.7536	-0.4192	-0.06173	0.1512	0.3532	-0.01659
G2	-0.7377	-0.8501	0.4701	1.2256	0.09672	-0.02221
G3	1.0204	0.8086	0.5991	1.0165	-0.7179	0.484

G4	2.9515	1.343	-1.8436	-0.1056	-0.3127	-0.101
G5	-1.2303	-0.6363	-0.1599	0.2304	0.5482	-0.1263
G6	-0.5089	0.5536	0.9662	-0.6791	-0.06064	0.5506
G7	0.7248	1.643	0.3577	0.9628	0.7153	-0.5913
G8	-2.7191	0.5524	-0.1995	-0.1626	0.1032	0.2471
G9	-1.853	-1.1603	-0.2089	0.6808	-0.2057	0.05611
G10	1.7328	-0.5988	-0.2128	0.01816	-0.778	0.1139
G11	-2.2024	0.6822	0.5453	-1.038	-0.2254	0.1638
G12	-1.9841	0.07195	-0.1463	0.483	0.1279	0.1922
G13	-1.5611	1.03	0.8072	-0.1668	0.1946	-0.01255
G14	-2.6839	0.447	-0.3817	-0.876	-0.3168	-0.3618
G15	2.5351	0.1804	-0.4693	-0.4995	0.7039	0.6972
G16	-1.7213	0.04629	-0.5949	0.221	0.6723	0.498
G17	-1.9036	-1.7525	0.1736	-0.5605	-0.01664	-0.1984
G18	-0.1019	-0.3849	-1.511	0.6023	-0.5566	-0.3338
G19	-1.5384	0.8307	-1.1724	-0.3507	-0.1188	-0.3694
G20	1.8772	-1.5292	-0.06309	-0.3319	-0.2375	0.4061
G21	2.3055	-1.7225	0.442513	-0.335	0.9589	-0.602
G22	0.0281	0.3524	0.841	-0.1834	0.3174	-0.08403
G23	4.9236	0.4754	0.3068	0.256	0.3271	0.06681
G24	1.6509	0.5748	-0.4216	-0.9075	0.06355	-0.05281
G25	-0.5508	-0.6847	0.7832	-0.2116	-0.9502	-0.2112
G26	-1.5219	-0.001042	-0.2894	1.6885	0.0782	0.1526
G27	1.4127	0.9303	1.1923	-0.2434	-0.3952	-0.4328
G28	-1.8212	0.4255	-0.0498	-0.6766	0.2109	-0.0359
G29	2.013	-1.2039	-0.4858	-0.7203	-0.05753	0.06843
G30	2.2174	-0.004175	0.7865	0.5125	-0.5217	-0.1448